UNITED STATES DISTRICT COURT
DISTRICT OF MINNESOTA

REGENTS OF THE UNIVERSITY OF MINNESOTA, Plaintiff, v. AT&T MOBILITY LLC, Defendant, ERICSSON, INC., and ALCATEL LUCENT USA INC., Defendants-Intervenors.	Civil Action No. 14-cv-4666 JRT-TNL **JURY TRIAL DEMANDED**
REGENTS OF THE UNIVERSITY OF MINNESOTA, Plaintiff, v. SPRINT SPECTRUM L.P., et al., Defendants, ERICSSON, INC., ALCATEL LUCENT USA INC., and NOKIA SOLUTIONS AND NETWORKS US LLC, Defendants-Intervenors.	Civil Action No. 14-cv-4669 JRT-TNL **JURY TRIAL DEMANDED**

REGENTS OF THE UNIVERSITY OF MINNESOTA, Plaintiff, v. T-MOBILE USA, INC., Defendant, ERICSSON, INC., ALCATEL LUCENT USA INC., and NOKIA SOLUTIONS AND NETWORKS US LLC, Defendants-Intervenors.	Civil Action No. 14-cv-4671 JRT-TNL **JURY TRIAL DEMANDED**
REGENTS OF THE UNIVERSITY OF MINNESOTA, Plaintiff, v. CELLCO PARTNERSHIP D/B/A VERIZON WIRELESS, Defendant, ERICSSON, INC., and ALCATEL LUCENT USA INC., Defendants-Intervenors.	Civil Action No. 14-cv-4672 JRT-TNL **JURY TRIAL DEMANDED**

REGENTS OF THE UNIVERSITY OF MINNESOTA'S
OPENING CLAIM CONSTRUCTION BRIEF

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I. INTRODUCTION

Regents of the University of Minnesota filed these actions to address infringement of five wireless communication patents[1] by the major cellular network providers: AT&T, Sprint, T-Mobile, and Verizon. Professor Georgios Giannakis and several of his students developed the patented technology at the University more than two decades ago. The asserted patents all stem from patent applications filed in the early 2000s.

The technology in this case relates to the improved performance of cellular networks. A cellular network includes fixed "base stations" often mounted on "cell towers" that are deployed throughout a wireless carrier's service area and communicate with mobile devices, such as phones, by exchanging radio signals.[2] This, in turn, allows a mobile device to communicate with other phones or with any device on the Internet, such as email servers or web sites.

To maintain a high quality of cellular service, the radio link between the base station and mobile device must be both fast and reliable. A fast radio link allows large volumes of data to be transmitted quickly, which enables data-intensive applications such as streaming video, gaming, and the like. A reliable radio link allows accurate data

[1] The patents include 7,251,768 ('768 patent), RE45,230 ('230 patent), 8,588,317 ('317 patent), 8,718,185 ('185 patent) and 8,774,309 ('309 patent), attached as Exhibits A-E of the Declaration of Jonathan Wells, Ph.D. Relating to Claim Construction (the "Wells Decl."). All other Exhibits referenced herein are attached to the Wells Declaration unless otherwise noted.

[2] The area served by a particular base station is known as a "cell."

reception even when the link is weak due to distance or environmental factors, which avoids interruptions in service due to lost signals.

The University patents disclose techniques that improve both the speed and the reliability of the radio link between the base station and mobile device. The five patents can be divided into two groups. The first group, which includes the ’230 and ’768 patents, is directed to digital coding techniques that improve the efficiency and accuracy of wireless digital transmissions. These techniques help the mobile device correctly interpret the signals received from a base station, even when the signal is weak or has been altered by interference, obstructions, or other factors. This allows each base station to cover a larger geographical area (cover more users) and provide a higher speed of service to those users.

The other three patents (the ’317, ’185, and ’309 patents, collectively “the ’317 family”) share a common specification and are directed to techniques for “training” a wireless receiver (such as a mobile device) to more accurately interpret transmissions from a particular transmitter (such as a base station). Training allows the receiver to identify, and thus correct for, certain non-ideal conditions in the wireless communication channel. As with the ’230 and ’768 patents, the techniques in the ’317 patent family are important for improving the speed and accuracy of a wireless communication system.

The parties have identified a total of 14 groups of related terms for construction. Most of the disputed terms come from the ’230/’768 patent claims, with a smaller number from the ’317 family. Throughout the claim construction process, the University has, where possible, adopted Defendants’ proposed language to reduce the number of

terms for construction. The University's proposals for the disputed terms are consistent with their ordinary meaning in the context of the patent specifications, except in those cases where the inventors clearly disclaimed certain subject matter or otherwise defined a term's meaning. By contrast, Defendants' proposals, in nearly every instance, improperly import details from preferred embodiments in the specification and contradict the use of the term throughout the intrinsic evidence. The University respectfully requests that the Court adopt the University's proposed constructions.

II. TECHNOLOGY BACKGROUND

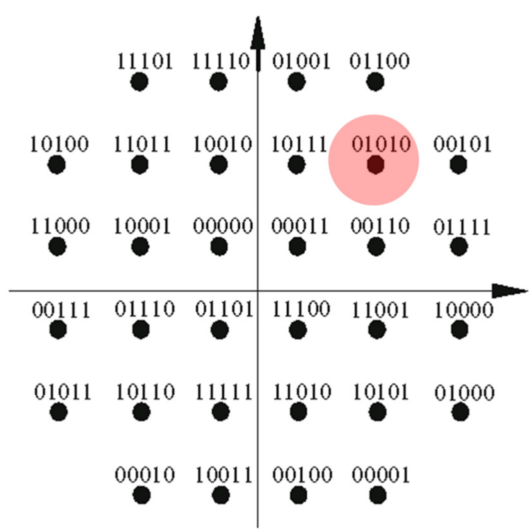
A. Wireless Data Transmission Overview

The claim construction disputes focus on complex concepts and terminology relating to the wireless communication of digital data. Digital data is information represented by discrete values (normally 1s and 0s) called bits. Wells Decl. ¶ 18. Most information processed by mobile devices—such as application programs (apps), documents, videos, and audio files—takes the form of digital data. *Id.*

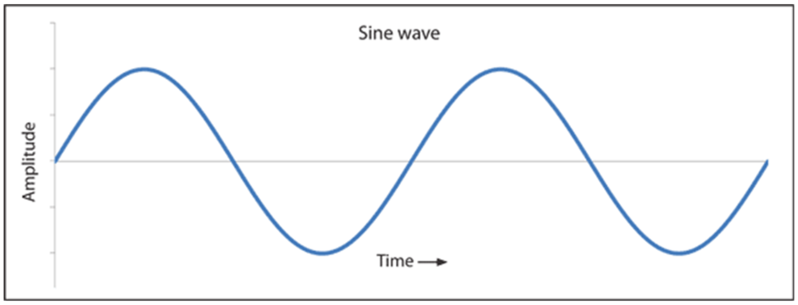
To transmit digital data over a wireless connection (such as between a base station and mobile phone), data must first be converted into a waveform that can be transmitted as a radio signal. *Id.* ¶¶ 18-20. This conversion process is called "modulation." *Id.* To modulate a waveform, a transmitter converts the stream of bits (1s and 0s) into a stream of "symbols," with each symbol corresponding to a unique pattern of bits. *Id.* For example, two bits can be arranged in four different combinations (*i.e.*, 00, 01, 10, and 11), which is also called an "alphabet" or "constellation" of four different symbols. *Id.* In sophisticated networks, more bits can be arranged in larger combinations to increase

the size of the constellation. *Id.* Increasing the amount of information transmitted with each symbol can increase the network speed, but a "crowded" constellation can also make it more difficult for the mobile device to determine which symbol it actually received if the signal is weak or altered by interference. *Id.*

The symbols in a constellation are often represented in an X-Y diagram (such as the example shown below). Wells Decl. ¶ 19. The various points in the diagram each represent a different symbol (corresponding to a particular combination of bits). In this example, there are 32 symbols in the constellation. *Id.* The distance of each point from the graph's origin represents the symbol's "amplitude" and the direction from the origin to the point represents the symbol's phase. *Id.* For example, the point highlighted in red corresponds to an amplitude of $3*\sqrt{2}$, and a phase of 45 degrees. *Id.*

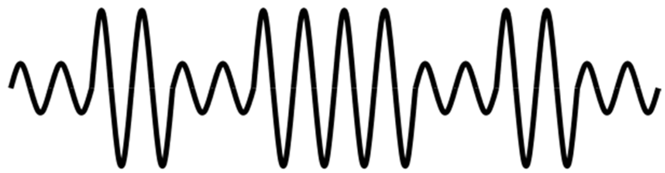


After converting the stream of bits into a stream of symbols, the symbols are fed to a modulator, which converts them into a waveform. Wells Decl. ¶ 20. The modulation starts with a regular cyclical (or "sinusoidal") waveform, called a "carrier wave":

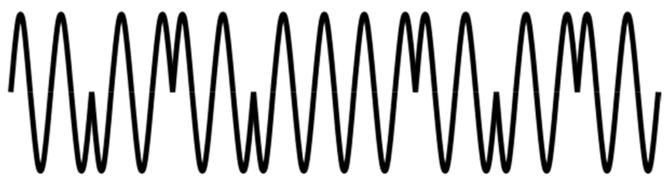


Id. The carrier wave is then modulated by changing its height or "amplitude," its "phase" (the starting point, in time, of the wave), or both, as each symbol is processed. *Id.* The following illustrations show how modulation changes the sinusoidal waveform:

Amplitude Modulated Signal



Phase Modulated Signal



Id. A few of the disputed terms here relate to the manipulation of the symbol's phase or amplitude before transmission.

Because each symbol in a constellation describes a unique combination of an amplitude and a phase, a waveform that is modulated using the amplitude and phase of a sequence of symbols can be interpreted at a receiver to uniquely represent the original sequence. Thus, when the receiver receives the waveform, it can detect how the amplitude and phase of the waveform change over time, convert that sequence of changes back into the stream of symbols, and ultimately recreate the original stream of bits that was transmitted. *Id.* ¶ 20.

B. Techniques for Dealing with Interference in Wireless Communications

When a modulated waveform is transmitted to a receiver over a radio link, ideally, the received signal would be identical to the transmitted signal. Wells Decl. ¶ 21. In the real world, however, the received signal can be distorted or lost due to environmental factors, such as interference, physical obstructions, or reflected signals. *Id.* These factors can hinder the receiver's ability to accurately reproduce the transmitted data. *Id.* For example, these distortions can cause "fades"—temporary losses of the signal at the receiver—that can prevent data from being received at a mobile device. *Id.*

To guard against the loss of transmitted data, communication systems typically augment the original digital data stream by adding additional, redundant information. Wells Decl. ¶ 21. The receiver can then use the redundant data to recover the original data even when a portion of the signal is lost. *Id.* Adding this type of redundant data to a data stream is referred to as "coding" or "encoding" the data. *Id.* Because the vulnerability of a signal to distortion becomes greater as the data rate or distance from the transmitter to the receiver increases, coding techniques that guard against fading can improve both the speed and effective range of the transmitter. *Id.*

The patents-in-suit discuss two different types of encoding. The first type, which the patents refer to as "error control coding," operates on the stream of bits before they are transformed into constellation symbols. *See, e.g.,* '768 Pat. at 1:50-55, 4:28-32, Fig. 1 ("Error Control Unit"). The second type, called "precoding," operates on constellation symbols, and modifies the symbol values to further improve the speed or accuracy of the transmission. *Id.* We discuss precoding in more detail later.

C. Transmission Over Multiple Channels and Multiple Antennas

In wireless transmission systems that predated the asserted patents, it was common for digital signals to be transmitted over a single "channel." Wells Decl. ¶ 22. In other words, the transmitter would send a single, sequential, stream of information to the receiver. In these systems, coding was typically limited to "error control coding." *Id.*

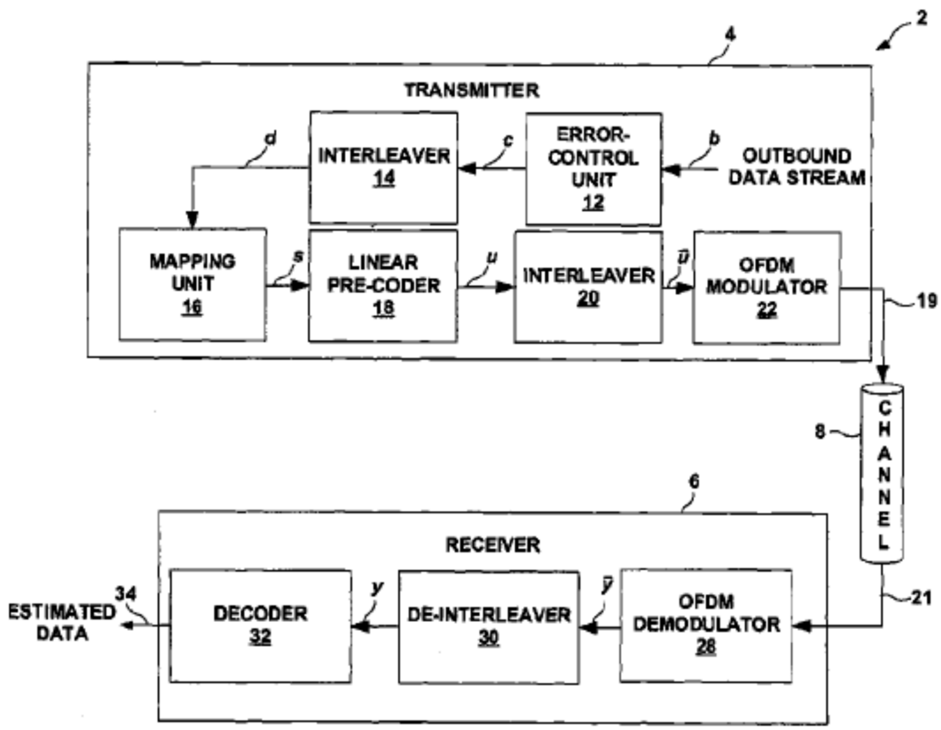
More recently, researchers developed technologies that transmit data over multiple parallel channels between a transmitter and a receiver. One example is a "multi-carrier" transmission system that allows a single transmitter to transmit parallel sequences of data simultaneously on multiple modulated carrier waves, called subcarriers, that operate at different frequencies. *Id*. One such multi-carrier technique, described in preferred embodiments of the University patents is "Orthogonal Frequency Division Multiplexing" (OFDM). *Id.* Another example of a parallel channel technique is Multiple-Input-Multiple-Output (MIMO), which uses multiple transmission antennas to transmit multiple parallel data sequences. *Id.*

These multi-channel transmission systems lend themselves to precoding techniques. In particular, the precoder combines or otherwise modifies the set of symbols corresponding to the information for transmission and sends the modified (or "precoded") symbols over parallel channels. Wells Decl. ¶ 23. This precoding allows the original information to be recovered even when some of the channels experience fades during transmission, and it may also increase the rate of data transmission. *Id.*

III. THE UNIVERSITY PATENTS

A. The Inventions of the ’230 and ’768 Patents

The ’768 and ’230 patents describe digital coding techniques that improve the efficiency and accuracy of wireless digital transmission systems. Figure 1 of the ’768 patent (reproduced below) shows an exemplary system that uses techniques claimed in the ’768 and ’230 patents. Wells Decl. ¶ 30; ’768 Patent at 3:35-38.



In this exemplary system, the “transmitter” (4) includes an “error control unit” (12) that performs error control coding to create a stream of coded bits. Wells Decl. ¶ 31; ’768 Pat. at 4:22-25. An “interleaver” (14) rearranges the order of the coded bits to create interleaved bits. Wells Decl. ¶ 30; ’768 Pat. at 4:33-35. Rearranging the bits guards against “burst” errors that affect a discrete portion of the stream of bits by more widely distributing the redundant data over a larger portion of the stream. *Id.* Next, the

"mapping unit" (16) generates a stream of constellation symbols based on the patterns of interleaved bits. Wells Decl. ¶ 30; '768 Pat. at 4:36-44. "Mapping" generally refers to the process of matching groups of bits from the sequence of bits to a constellation symbol. *Id.* The "linear precoder" (18) "precodes" the symbols by combining or otherwise modifying them in various ways to create blocks of precoded symbols. Wells Decl. ¶ 30; '768 Pat. at 4:44-49. Another "interleaver" (20) then rearranges the order of the pre-coded symbols, which spreads the data to across subcarriers that are spaced further apart. Wells Decl. ¶ 30; '768 Pat. at 4:50-67. This protects against errors that affect specific ranges of frequencies in a multi-carrier system. *Id*. Finally, an "OFDM modulator" 22 uses the different precoded symbols in the block to modulate respective subcarriers for transmission over the wireless "channel" (8) to a receiver (6). *Id.* The receiver "demodulates" the received waveform to recreate the stream of precoded symbols, de-interleaves that stream, and then decodes the de-interleaved stream to recover the original stream of bits. Wells Decl. ¶ 30; '768 Pat. at 5:14-27.

The asserted claims of the '768 and '230 patents recite various structural elements of the communication system, as well as corresponding method claims. For example, claim 1 of the '768 patent is directed to certain elements of the transmitter:

> A wireless communication device comprising:
>
> An **error-control coder** that applies an error correction coder to produce an encoded data stream of information bearing symbols;
>
> A bit **interleaver** to produce an interleaved data stream in which neighboring data bits of the encoded data stream are positioned to be mapped to different constellation symbols;

> A **mapping unit** to map the interleaved data stream to the constellation symbols, wherein the constellation symbols are selected from a constellation having a finite alphabet;
>
> A **precoder** that applies a liner [sic:linear] transformation to the constellation symbols to produce precoded symbols, wherein the precoded symbols are complex numbers that are not restricted to the finite alphabet of the constellation;
>
> A symbol **interleaver** to process the precoded symbols to produce permuted blocks of the precoded symbols; and
>
> A **modulator** to produce an output waveform in accordance with the permuted blocks of precoded symbols for transmission through a wireless channel.

The elements of the asserted ’230 and ’768 claims responsible for most of the claim construction disputes relate to the “precoder” and to the process of “linear precoding.”

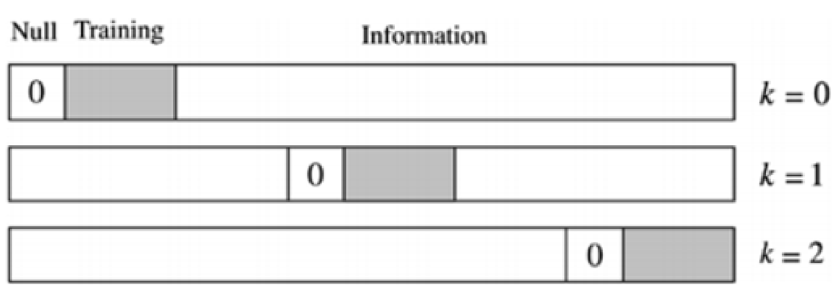
B. The Inventions of the ’317 Patent Family

As noted previously, the ’317 patent family is directed to techniques for “training” the receiver of a wireless communication to correct for certain non-ideal conditions in the wireless communication channel. Wells Decl. ¶ 32. The transmitter trains the receiver by transmitting predefined values, called “training symbols,” at pre-defined time intervals. *Id.*; ’317 Pat. at 2:16-36, 4:22-45. The receiver knows the values of the training symbols and when to expect them, which allows it to compare the values actually received with the expected values and thereby determine how to adjust the received values to correct for the non-ideal conditions. Wells Decl. ¶ 32.

One type of training symbol is called a “null subcarrier.” Wells Decl. ¶ 33; ’317 Pat. at 2:27-32. As its name suggests, a null subcarrier is the transmission of no value on a particular subcarrier in a multi-carrier transmission system. Wells Decl. ¶ 33. The ’317 family patents describe techniques for inserting training symbols, including null

subcarriers, into blocks of "information bearing symbols" (*i.e.*, message data) for transmission. *Id.* The claimed techniques all use a "hopping code"—a formula whose value changes over time—to determine where in the blocks the null subcarriers (and other training symbols) will be inserted. *Id.*; '317 Pat. at 2:30-32, 4:24-31.

The following example illustrates these techniques. It shows three consecutive blocks of output symbols for transmission over time. Wells Decl. ¶ 34; '317 Pat. at 13:23-45. In each block, a hopping code is used to insert a null subcarrier (indicated by the symbol "0") and an adjacent block of other (non-zero) training symbols (indicated by the grey area) at different positions. *Id.* The remainder of each block (the white space) represents information bearing symbols (*i.e.,* user data) that will be transmitted along with the training symbols. *Id.*



The asserted claims of the '317 family recite various techniques for inserting null subcarriers, and training symbols more generally, into output blocks for transmission in OFDM (multi-carrier) and MIMO (multi-antenna) transmission systems. Claim 13 of the '309 patent sets forth an example of these techniques:

A method comprising:

encoding information-bearing symbols;

> **forming two or more blocks of output symbols** for orthogonal frequency division multiplexing (OFDM) transmissions over a multiple-input multiple-output (MIMO) channel, **wherein the forming comprises inserting training symbols and null subcarriers within two or more blocks of the encoded information-bearing symbols at positions determined by a hopping code,** wherein the hopping code is a function of the number of antennas for transmitting the transmission signals; and
>
> transmitting, via two or more antennas, transmission signals in accordance with the two or more blocks of output symbols.

The claim construction disputes regarding the ’317 family claims involve the meaning of the terms “null subcarrier” and “training symbol,” and the way in which the claims define the how training symbols and null subcarriers must be positioned in blocks of information bearing symbols.

IV. LEGAL STANDARDS

The “words of a claim are generally given the[] ordinary and customary meaning” that they “would have to a person of ordinary skill in the art in question at the time of the invention.” *Phillips v. AWH Corp.*, 415 F.3d 1303, 1312–13 (Fed. Cir. 2005) (en banc) (citation omitted). In construing claims, “the court looks to those sources available to the public that show what a person of skill in the art would have understood disputed claim language to mean. Those sources include the words of the claims themselves, the remainder of the specification, the prosecution history, and extrinsic evidence concerning relevant scientific principles, the meaning of technical terms, and the state of the art.” *Id.* at 1314 (internal quotations and citation omitted). The specification is “the single best guide to the meaning of a disputed term” and is usually “dispositive.” *Id.* at 1315.

The Federal Circuit has recognized "only two exceptions" to the rule that claim terms are given their ordinary and customary meaning: "1) when a patentee sets out a definition and acts as his own lexicographer, or 2) when the patentee disavows the full scope of a claim term either in the specification or during prosecution." *Thorner v. Sony Comput. Entm't Am. LLC*, 669 F.3d 1362, 1365 (Fed. Cir. 2012). In other words, it is improper to limit the claims to the specific embodiments in the specification. *Phillips*, 415 F.3d at 1323. It is "not enough that the only embodiments, or all of the embodiments, contain a particular limitation" to limit the claims beyond their plain meaning. *Thorner*, 669 F.3d at 1366. A disclaimer or disavowal of claim scope in the specification or during the prosecution of the patent must be "clear and unmistakable," requiring "expressions of manifest exclusion or restriction." *Id*. at 1366-67. It must "make[] clear that the invention does not include a particular feature." *SciMed Life Sys. Inc. v. Advanced Cardiovascular Sys., Inc.*, 242 F.3d 1337, 1341 (Fed. Cir. 2001).

A court may also consider extrinsic evidence, which includes "all evidence external to the patent and prosecution history, including expert and inventor testimony, dictionaries, and learned treatises." *Id.* However, "while extrinsic evidence 'can shed useful light on the relevant art,'" it is "less significant than the intrinsic record in determining the legally operative meaning of claim language." *Id.*

V. PROPOSED CONSTRUCTIONS OF DISPUTED CLAIM TERMS

The University currently asserts the following claims from the patents-in-suit:

Patent	Asserted Claims
’768	1, 8, 9, 11, 13, 17-18, 21
’230	1-3, 13, 16-17, 30, 33-34, 36, 42-46, 49-50, 56, 58, 64-65, 68-69, 72, 77
’317	1, 15
’185	9-11
’309	13, 16-17, 19, 22-24

The parties disagree on the meanings of numerous terms and thus, for ease of presentation, we have arranged them into different groups. We first address the terms from the ’768 and ’230 patents, and then those from the ’317 patent family.

A. Linear Precoding Terms (’768 Patent)

Terms	University Proposal	Defendants’ Proposal
“a precoder that applies a liner [sic: linear] transformation to the constellation symbols to produce precoded symbols” (768:1) “a precoder that linearly precodes the constellation symbols” (768:13) “linearly precoding the constellation symbols by applying a linear transformation to produce precoded symbols” (768:21)	**“a precoder that applies…” / “a precoder that linearly precodes”**: a precoder that applies a linear transformation that transforms a block of input symbols into a block of output symbols in which each output symbol is a linear combination, or weighted sum, of input symbols” **“linearly precoding…”:** applying a linear transformation that transforms a block of input symbols into a block of output symbols in which each output symbol is a linear combination, or	**“a precoder that applies…” / “a precoder that linearly precodes”**: a precoder that applies a linear transformation to combine two or more of the constellation symbols with each other to produce precoded symbols, wherein the linear transformation has the following properties: 1) for any constellation symbols a and b, f(a + b) = f(a) + f(b), 2) for any scalar k, f(k*a) = k*f(a). **“linearly precoding”:** a precoder that applies a linear transformation to combine two or more of the constellation symbols with

	weighted sum, of input symbols **"linear transformation":** a mathematical operation on vectors, f(x), which has the property that for any vectors a and b that are valid arguments to f, f(a+b) = f(a) + f(b), and for any scalar k, f(k*a) = k*f(a). The linear transformation does not include the operation of using a spreading sequence of chips to spread each information-bearing symbol over a set of data symbols.	each other to produce precoded symbols, wherein the linear transformation has the following properties: 1) for any constellation symbols a and b, f(a + b) = f(a) + f(b), 2) for any scalar k, f(k*a) = k*f(a).

Independent claims 1, 13, and 21 of the '768 patent all recite a "precoder" that applies a "linear transformation" to constellation symbols. The dispute here relates to the meanings of the terms "precoder" and "linear transformation."

1. A "Precoder" Produces a Weighted Sum of the Input Symbols.

The '768 patent specification explains that "linear precoding" of constellation symbols improves diversity gain and system performance in an OFDM system with multiple subcarriers. Wells Decl. ¶ 38; '768 Pat. at 2:18-19. The specification further states that "linear precoding" is a term of art that means "sending linear combinations of symbols" over a communication channel. Wells Decl. ¶ 39; Ex. G at 3-4 ("In the signal processing literature, sending linear combinations of symbols is also known as *linear*

precoding[.]").[3] A "linear combination" of symbols is, in turn, a weighted sum of those symbols. Wells Decl. ¶¶ 23-26, 40; Ex. I at UMN0149588 (defining "linear combination" as "a sum of the respective products of the elements of some set with constant coefficients"). A weighted sum is generated by multiplying each value by some number (a weight), and then adding the results. Wells Decl. ¶ 23.

In view of the patent's definition of "linear precoding" and the ordinary meaning of a "linear combination" from that definition, "linear precoding" requires that the precoder produce an output that is a linear combination, or weighted sum, of the input symbols. The University's proposal reflects these requirements. Defendants, on the other hand, do not provide any construction for "precoder" or "precoded symbols" (and opt to restate those claim terms in their proposal).

2. The Inventors Disclaimed Certain Coding Operations from the Meaning of "Linear Transformation" During Prosecution.

A second dispute relates to the type of "linear transformation" that the claimed "precoder" or "precoding" must perform to produce the precoded symbols. Defendants' proposal is incorrect because it recites the ordinary meaning of "linear transformation"[4] and fails to account for the patentees' clear and unmistakable disclaimer of certain subject matter during prosecution. As previously noted, the proper construction of a

[3] Both the '768 and '230 patents incorporate five provisional patent applications into their specifications, including Provisional App. No. 60/374,935 (the "'935 provisional"), which is Exhibit G to the Wells Declaration. *E.g.*, '768 Pat. at 1:7-12. Thus, references to these provisional applications apply to both patents.

[4] That ordinary meaning is a mathematical operation on vectors f(x), which has the property that for any vectors a and b that are valid arguments to f, f(a + b) = f(a) + f(b), and for any scalar k f(k*a) = k*f(a). *See* Wells Decl. ¶ 40; Ex. J at 211.

claim term will differ from the ordinary meaning when "the patentee disavows the full scope of a claim term … during prosecution." *Thorner*, 669 F.3d at 1365.

During prosecution of the '768 patent, the patentees clarified the scope of "linear transformation" by disclaiming a specific operation disclosed in a patent to Kaiser (U.S. Patent No. 6,188,717). Wells Decl. ¶ 42, Ex. K (Kaiser Patent), Ex. L ('768 File History). Specifically, the examiner rejected certain claims because, according to the examiner, an element in Kaiser called the "spreading [sic: spread] and sequence imposition unit (4)" corresponded to a "precoder that linearly precodes the encoded data stream" in the claims. Wells Decl. ¶ 42, Ex. L at UMN0000200-201. Kaiser's spreading technique, however, was different from the invention because it first "spread" each symbol into a sequence of multiple symbols (by multiplying each original symbol by a sequence of binary values called "chips") and then "superimposed" the sequences corresponding to each original symbol to create a final set of symbols, whereas the linear transformation of the invention operated on a block of input values by directly creating weighted sums of those values without the need for any spreading step or the use of chips. Wells Decl. ¶ 42-44, Ex. K at 5:33-50, Figs. 2, 4. In response to the examiner's rejection, the inventors clearly and unmistakably argued that Kaiser's technique was not a "linear transformation" within the meaning of their claims:

> The operation [in Kaiser's spreading and sequence imposition unit] of spreading a single information-bearing symbol over a set (L) of data symbols ***is different from linearly precoding*** a complex field of each original symbol ***(i.e., applying a linear transformation)***… . ***There is no evidence of record to indicate that applying a spreading sequence linearly transforms*** the complex field of the information-bearing symbols at all.

Wells Decl. ¶¶ 44-45, Ex. M at UMN0000233 ('768 File History) (emphasis added).

In light of this clear disavowal, the concept of a "linear transformation" in the patents cannot encompass the operation of using a spreading sequence of chips to spread each information-bearing symbol over a set of data symbols, as described in Kaiser. Accordingly, the construction of the "linear transformation" should exclude the operation of "using a spreading sequence of chips to spread each information-bearing symbol over a set of data symbols," as clearly stated by the inventors during prosecution.[5] Defendants' proposal would encompass the very subject matter that the patentees disclaimed and, therefore, is incorrect.

B. Linear Transformation Terms ('230 Patent)

Terms	University Proposal	Defendants' Proposal
"applies a linear transformation to the stream of information bearing symbols" (230:1)	**"applies/applying a linear transformation":** transforms/transforming blocks of symbols from the stream of information bearing symbols, using a linear transformation to produce symbols that are linear combinations, or weighted sums, of information bearing symbols. **"linear transformation":** *see* proposed construction for '768 patent	Applies/applying a time invariant linear transformation to the stream of information bearing symbols by combining two or more of the information bearing symbols with each other to produce precoded symbols, wherein the linear transformation has the following properties: 1) for any constellation symbols a and b, f(a + b) = f(a) + f(b), 2) for any scalar k, f(k*a) = k*f(a).
"applying a linear transformation to the stream of information bearing symbols" (230:16)		
"applying a linear transformation to a stream of information bearing symbols"		

[5] The dispute regarding the disclaimer is highly relevant here because Defendants contend that various Kaiser references, which disclose the same kinds of spreading techniques as the Kaiser patent identified by the examiner, invalidate the claims of the '768 patent.

(230:49, 64)		
"applies a linear transformation to a stream of information bearing symbols" (230:68)		

Like the '768 patent, each claim of the '230 patent includes a term that describes the process of precoding symbols using a linear transformation.[6] Defendants' construction includes three errors.

First, as with the '768 claims addressed in the previous Section, the parties' constructions here differ in that the University proposal refers to "linear combinations, or weighted sums, of information bearing symbols" and Defendants fail to provide a construction and simply refer to "precoded symbols."

Second, Defendants' proposal wrongly omits the exclusion of a spreading sequence of chips that was disclaimed from the scope of "linear transformation" during the prosecution of the '768 patent. Because the '230 patent is related to the '768 patent, the disclaimer of claim scope for the "linear transformation" applies to the construction of "linear transformation" in the '230 patent as well. *See Omega Eng'g, Inc. v. Raytek Corp.,* 334 F.3d 1314, 1334 (Fed. Cir. 2003) ("[T]he same claim term in the same patent or related patents carries the same construed meaning."); *Jonsson v. Stanley Works*, 903

[6] Although the words "precoder" and "precoding" are not used in the '230 claims, each claim specifies that the result of the linear transformation is a stream of "precoded symbols."

F.2d 812, 818 (Fed. Cir. 1990) (finding arguments made during prosecution history of related patent relevant to construction of disputed term).

Defendants' proposal is also wrong because it includes the phrase "time invariant," which is inconsistent with the ordinary meaning of the "linear transformation" and lacks support in the intrinsic evidence. Wells Decl. ¶ 46. In particular, the '230 patent does not require that a linear transformation be time invariant. *Id.* Rather, the '230 specification expressly notes that "time-varying precoders may be useful for certain purposes." *Id.*; '230 Pat. at 1:11-18; Ex. H at UMN0000966. Moreover, by limiting the claim to a "time invariant linear transformation," Defendants necessarily concede that the ordinary meaning of "linear transformation" does not require time invariance.

C. Interleaver Terms ('768 & '230 Patents)

Term(s)	University Proposal	Defendants' Proposal
"interleaved data stream" (768:1, 13, 21)	a data stream that is generated using an interleaver, which is an electronic circuit or computer implemented algorithm that takes an ordered set of values and reorders them	bits that are the same as the bits of the encoded data stream that have been reordered so that adjacent bits are separated
"a symbol interleaver to process the precoded symbols to produce permuted blocks of the precoded symbols" (768:1) "a symbol interleaver to process the precoded data stream to produce	an electronic circuit or computer-implemented algorithm that takes an ordered set of precoded symbols and reorders them	an electronic circuit or computer-implemented algorithm that takes the precoded symbols and reorders them to separate adjacent symbols

permuted blocks of precoded symbols" (768:13)		
"processing the preceded [sic:precoded] symbols to produce permuted blocks of the preceded [sic:precoded] symbols" (768:21)	processing an ordered set of precoded symbols by reordering them	taking the precoded symbols and reordering them to separate adjacent symbols
"an interleaver that interleaves the encoded symbols to produce interleaved symbols" (230: 1)	an electronic circuit or computer-implemented algorithm that takes an ordered set of encoded symbols and reorders them	an electronic circuit or computer-implemented algorithm that takes the encoded symbols and reorders them to separate adjacent symbols
"interleaving the coded symbols to produce interleaved symbols" (230: 13, 16)	taking an ordered set of coded symbols and reordering them	taking the coded symbols and reordering them to separate adjacent symbols
"interleaving the coded bits to produce interleaved bits" (230: 49)	taking an ordered set of coded bits and reordering them	taking the coded bits and reordering them to separate adjacent bits
"a de-interleaver that reassembles blocks of linearly precoded symbols from the demodulated data stream" (768:8)	an electronic circuit or computer implemented algorithm that rearranges received demodulated data values corresponding to transmitted precoded symbols to reverse an interleaving step applied to the precoded symbols	an electronic circuit or computer-implemented algorithm that takes the demodulated data stream and reassembles blocks of linearly precoded symbols that had been reordered to separate adjacent symbols

The '768 and '230 patents claim systems and methods that include one or more "interleavers" or "interleaving" steps. Although there are several phrases at issue, they all focus on the same dispute over what it means to "interleave" bits or symbols.

"Interleaving" is a term of art in the field of digital wireless transmission systems, which means shuffling or reordering individual pieces of data, such as bits or symbols, before transmission. Wells Decl. ¶ 48, Ex. R at 1 (describing an interleaver as a "hardware device commonly used in conjunction with error correcting code" that "takes symbols from a fixed alphabet as the input and produces the identical symbols at the output in a different temporal order"); Ex. S. This reordering makes coded data (data that includes redundant information to protect against data loss) more robust by spreading it throughout the transmitted data stream. Wells Decl. ¶ 48.

Consistent with its ordinary meaning, both parties agree that an interleaver "reorders" data. The parties also agree that an interleaver is "an electronic circuit or computer implemented algorithm" that performs interleaving. *Id.* ¶ 49. Similarly, a de-interleaver is an "electronic circuit or computer implemented algorithm" that performs de-interleaving. *Id.* ¶ 52.

The dispute centers around the format of the bits/symbols after the interleaving process. Defendants wrongly require that ***every*** adjacent piece of data in the stream is separated from its neighbor. Neither the ordinary meaning of "interleaving" and "interleaver," nor the intrinsic evidence, supports such a requirement. Instead, the '230 and '768 patents both teach that the preferred embodiments can include a "random" interleaver. '230 Pat. Cert. of Correction at 11; '768 Pat. at 10:65-11:2; *see also* Wells Decl. ¶ 50. As its name suggests, a random interleaver reorders the input data in a random fashion, with the particular order based on a random number generator. Wells Decl. ¶ 50; *see also* Ex. R at 1 ("A variation of a block interleaver is a pseudorandom

block interleaver, in which data is written in memory in sequential order and read in a pseudorandom order”). While randomly reordering a data set will disperse the data and achieve the benefits of interleaving, there is no guarantee that every pair of adjacent values will be separated, and thus a random interleaver (and random interleaving) would not fall within the scope of Defendants’ proposed construction. Wells Decl. ¶ 50. A claim construction that excludes preferred embodiments is “rarely, if ever, correct.” *Vitronics Corp. v. Conceptronic, Inc.*, 90 F.3d 1576, 1583 (Fed. Cir. 1996).

Defendants’ proposal is also wrong because it excludes interleaving groups of bits or symbols, which necessarily remain together after interleaving. Wells Decl. ¶ 51. Nothing in the claims, specifications, or file histories of any of the patents excludes this type of interleaving. Without words of exclusion in the intrinsic evidence, it is improper to limit the claims beyond their ordinary meaning. *Thorner*, 669 F.3d at 1365. Defendants apparently seek to narrow the “interleaving” term in the claims because, in certain circumstances, the wireless networks accused of infringement interleave groups of four symbols (called “quadruplets”) rather than interleaving on a symbol-by-symbol basis. Wells Decl. ¶ 51, Ex. U (stating that an “interleaver” performs the function of interleaving “quadruplets” in an LTE network). Defendants’ litigation-inspired attempt to exclude this ordinary meaning of “interleaver” is improper. *Vita-Mix Corp. v. Basic Holding, Inc.*, 581 F.3d 1317, 1324 (Fed. Cir. 2009) (“Claims are properly construed without the objective of capturing or excluding the accused device.”).

D. Multiple Matrices Terms ('230 Patent)

Terms	University Proposal	Defendants' Proposal
"wherein the linear transformation is based on multiple matrices" (230: 30, 33, 40, 43, 64, 68)	The linear transformation can be expressed as multiplication by a matrix that is the product of at least two other matrices	Indefinite
"wherein the first matrix is based on a fast Fourier transform (FFT) matrix, and wherein the second matrix is based on a diagonal matrix" (230: 30, 40, 64, 68)	wherein the first matrix can be expressed as a mathematical operation that includes a Fast Fourier transform (FFT) matrix, and wherein the second matrix can be expressed as a mathematical operation that includes a diagonal matrix	The term "based on" is indefinite. Should the court find this term to not be indefinite, the linear transformation must be represented in the following order: [FFT matrix]*[Diagonal matrix]
"wherein the linear transformation is based on a Fourier transform" (230:77)	the linear transformation can be expressed as a mathematical operation that includes a Fourier transform	Indefinite

The disputed claim terms in this group all recite further mathematical properties of the linear transformations discussed previously. These terms refer to in-depth mathematical concepts, which we introduce before addressing the specific claim construction disputes.

1. The disputed terms focus on well-known aspects of matrix arithmetic.

As mentioned previously, linear precoding involves creating different weighted sums of two or more input symbols by combining information from those symbols (*e.g.*, by addition) and then transmitting those combined values over parallel channels. Wells

Decl. ¶ 23. In wireless communications, the operation of a linear precoder is often described using a mathematical construct called a "matrix." *Id.* ¶ 24. A matrix is a grid of values (or elements) arranged in columns and rows (an example is shown below). A matrix that only contains a single column of elements is called a "vector." *Id.* ¶ 25.

$$\begin{bmatrix} -1.3 & 0.6 \\ 20.4 & 5.5 \\ 9.7 & -6.2 \end{bmatrix}.$$

Matrices have well-defined rules for adding and multiplying them, and thus are useful to describe the arithmetic operation of precoders. *Id.* ¶ 26. The arithmetic expressions of matrices can be used as shorthand to describe a series of operations performed by the precoder on the matrix elements. *Id.* Consistent with the '230 patent, the operation of a precoder is typically described by defining a vector of input values and then defining the precoder itself as one or more matrices that will be applied to the input values to create different weighted sums of those inputs. *Id.* For example, a precoder (*i.e.*, the matrix with elements a through d) that creates two different weighted sums of the inputs *x* and *y* can be described by the following matrix multiplication expression:[7]

$$\begin{bmatrix} a & b \\ c & d \end{bmatrix} * \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} a * x + b * y \\ c * x + d * y \end{bmatrix}.$$

Id. In some cases, a precoder matrix may be described as the product of two other matrices. In other words, a precoder matrix C might be defined as the product of two matrices A and B (*i.e.*, C = A*B). *Id.* ¶ 27. Just as in ordinary arithmetic, multiplying a

[7] The "*" symbol here represents multiplication.

vector of input values by "precoder C" is mathematically equivalent to multiplying those input values by both A and B. *Id.*

Consistent with this mathematical relationship, the'230 patent describes precoders that are the product of two component matrices. *Id.* ¶ 28. The '230 patent, for example, discloses a class of precoders, referred to as "LCP-B," that can be used in a MIMO system with multiple transmission antennas. '230 Pat. Cert. of Correction at 6. These LCP-B precoders are described in terms of a precoder matrix Θ (theta):

$$\Theta = F_{N_t}^T diag(1,\ \alpha,\ \ldots,\ \alpha^{N_t - 1}), \alpha := e^{j2\pi/P}$$

Id.; *see also* Wells. Decl. ¶ 28. As the equation shows, the Θ matrix is the product of two component matrices: $F_{N_t}^T$, which is a well-known matrix called an "inverse fast Fourier transform" (IFFT) and $diag(1,\ \alpha,\ \ldots,\ \alpha^{N_t-1}),\ \alpha := e^{j2\pi/P}$, which defines a "diagonal matrix." Wells Decl. ¶¶ 29, 56. Under the rules of matrix arithmetic described previously, multiplying an input matrix by Θ is equivalent to first multiplying it by the diagonal matrix and then by the IFFT matrix. *Id.* ¶ 29.

The '230 patent includes several claims that are directed to linear transformations with the same general structure as LCB-B. Although some of these terms contain complicated mathematical expressions, their proper construction is ultimately a straightforward application of mathematical principles that are well-known to those of ordinary skill in the art.

2. The proper construction of the disputed terms applies unambiguous, well-known mathematical expressions.

Several claims in the ’230 patent include the phrase “wherein the linear transformation is based on multiple matrices comprising a first matrix and a second matrix.” This phrase is consistent with the patent’s disclosure that a matrix defining a linear transformation may, in turn, be defined as the product of multiple matrices. Wells Decl. ¶ 60; *see also* ’230 Pat. Cert. of Correction at 6. Consistent with this ordinary meaning, the proper construction of this term is “the linear transformation can be described as multiplication by a matrix that is the product of at least two other matrices comprising a first matrix and a second matrix.” *Id.*

The next disputed phrase in this group immediately follows the first in claim 30 of the ’230 patent and further specifies the first and second matrices: “wherein the first matrix is based on a fast Fourier transform (FFT) matrix, and wherein the second matrix is based on a diagonal matrix.” The parties do not dispute the meaning of “fast Fourier transform (FFT) matrix” and agree on the meaning of “diagonal matrix.”[8] Instead, the disagreement relates to the words “based on” in the disputed phrase. One of ordinary skill in the art would understand this language, when read in light of the specification and its examples of operations that involve matrix multiplication, to mean “wherein the first matrix can be expressed as a mathematical operation that includes a Fast Fourier transform (FFT) matrix, and wherein the second matrix can be expressed as a

[8] Both of those terms have well-understood meanings in the art. Wells Decl. ¶¶ 61-64; Joint Claim Construction Statement.

mathematical operation that includes a diagonal matrix." Wells Decl. ¶ 60. Further, because of the mathematical principles discussed previously, it is incorrect for Defendants to require that the matrices be applied in a specific order. *Id.* It also contrary to well established law that labels like "first" and "second" imply any kind of temporal order unless the claim language expressly or inherently requires it:

> **The use of the terms "first" and "second" is a common patent-law convention to distinguish between repeated instances of an element or limitation.** *See, e.g., Anchor Wall Sys., Inc. v. Rockwood Retaining Walls, Inc.*, 340 F.3d 1298, 1304 (Fed. Cir. 2003) (first and second sidewall surfaces); *Springs Window Fashions LP v. Novo Indus., L.P.*, 323 F.3d 989, 992 (Fed. Cir. 2003) (first and second opposed ends). In the context of claim 1, **the use of the terms "first** ... pattern" **and "second ...** pattern" is equivalent to a reference to "pattern A" and "pattern B," **and should not in and of itself impose a serial or temporal limitation onto claim 1.**

3M Innovative Props. Co. v. Avery Dennison Corp., 350 F.3d 1365, 1371 (Fed. Cir. 2003) (emphasis added); *see also Gillette Co. v. Energizer Holdings, Inc.*, 405 F.3d 1367, 1373 (Fed. Cir. 2005) (explaining that the terms "first, second, [and] third" refer to different blades and are not intended to show "a consecutive numerical limit but only to distinguish or identify various members of the group [of blades].").

The third disputed phrase appears in claim 77 of the '230 patent and requires that the linear transformation be "based on a Fourier transform." Consistent with the proposal for the other disputed phrases in this group, a transformation that is "based on a Fourier transform" should be construed to mean one that can be "expressed as a mathematical operation that includes a Fourier transform." *Id.* ¶ 65.

3. The disputed terms are not indefinite.

Defendants ask the Court to conclude that every claim that contains one of the disputed terms in this group are invalid as indefinite. A claim is indefinite only if, when "read in light of the specification delineating the patent, and the prosecution history, [it] fail[s] to inform, with reasonable certainty, those skilled in the art about the scope of the invention." *Nautilus, Inc. v. Biosig Instruments, Inc.*, 134 S. Ct. 2120, 2124 (2014). Here, as demonstrated previously, these terms all provide reasonable certainty as to the type of linear transformations that fall within their scope. Wells Decl. ¶¶ 59, 60-65. Accordingly, the Court should reject Defendants' assertions of indefiniteness.

E. Unitary Matrix Term ('230 Patent)

Term	University Proposal	Defendants' Proposal
"applying a unitary matrix" (230:3, 230:18)	performing a mathematical operation that, when expressed in matrix form, includes multiplication with at least a unitary matrix	performing a mathematical operation that, when expressed in its matrix form, is multiplication by a unitary matrix

Claim 18 of the '768 patent and claims 3 and 18 of the '230 patent recite language that defines the precoder or linear transformation in terms of a "unitary matrix."[9] The parties have agreed to the meaning of the "unitary matrix" term from '768 patent:

[9] A unitary matrix is a well-known mathematical term that refers to matrices having complex values and certain other properties. *See* Wells Decl. ¶ 54. The parties do not dispute the definition of a "unitary matrix."

Term	Agreed Construction
"linear precoder comprises a unitary matrix"	a precoder that performs a mathematical operation that, when expressed in its matrix form, includes multiplication by a unitary matrix.

The parties' agreed construction establishes that the transformation performed by the linear precoder can be expressed as a mathematical operation that "includes" multiplication by a unitary matrix, but may also include other operations as well. In contrast, the dispute concerning the corresponding phrase in the '230 patent—"applying a unitary matrix"—centers on whether the linear transformation must consist ***only*** of multiplication by a unitary matrix (as Defendants propose), or whether it, like the '768 claim term, permits other operations in addition to multiplication by a unitary matrix.

Defendants' proposal to limit the disputed term to only multiplication by a unitary matrix is wrong. First, claim 3 depends from claim 1 of the '230 patent, which uses the word "comprising" to describe its elements. Similarly, claim 18 states that "applying the linear transformation … ***comprises*** applying a unitary matrix." When used in a patent claim, the words "comprises" and "comprising" signal that the claim is open-ended, meaning that an instance of the claimed invention must include the listed limitations, but it may include other elements not listed in the claim as well. *Vivid Techs., Inc. v. Am. Sci. & Eng'g, Inc.*, 200 F.3d 795, 811 (Fed. Cir. 1999) ("[T]he signal 'comprising' . . . is generally understood to signify that the claims do not exclude the presence in the accused apparatus or method of factors in addition to those explicitly recited."). Because claims 3 and 18 are open ended claims, Defendants' proposal, which allows multiplication by a unitary matrix and nothing else, is wrong as a matter of law. *Smith & Nephew, Inc. v.*

Ethicon, Inc., 276 F.3d 1304, 1311 (Fed. Cir. 2001) (vacating summary judgment of noninfringement because district court erred in construing method claim with signal "comprising" as limited to certain recited steps).

Moreover, the claim language contradicts Defendants' narrow interpretation. Claim 1 requires, *inter alia*, an encoder that "applies a linear transformation to [a] stream of information bearing symbols." Claim 3 limits claim 1 by specifying that the encoder "applies the linear transformation by applying a unitary matrix." Claim 16 (from which claim 18 depends), requires "applying a linear transformation to a stream of information bearing symbols," and claim 18 further limits claim 16 by specifying that the applying the linear transformation comprises "applying a unitary matrix." Nothing in this language requires (or even suggests) that the encoder applies ***only*** a unitary matrix or that the linear transformation is limited to applying ***only*** a unitary matrix. Rather, the proper reading of this language requires only that the mathematical expression of the linear transformation must include applying a unitary matrix.

F. Linear Combination Term ('230 Patent)

Term	University Proposal	Defendants' Proposal
Subcarriers carry different linear combinations of the information symbols (230: 2, 17)	The different subcarriers carry different weighted sums of the stream of information symbols transformed by the second encoder	Subcarriers carry different linear combinations of the stream of information symbols transformed by the second encoder

The dispute here relates to whether the jury should be given a construction for the phrase "linear combinations." The University's proposal defines that term to be a

"weighted sum," which clarifies its meaning using less technical language. *See* Wells Decl. ¶ 67. Defendants' proposal, on the other hand, restates the term without further explanation. Because jurors will most likely be unfamiliar with the meaning of this phrase, Defendants apparently would rather not provide any guidance (and thus be free to argue any meaning they desire). The University respectfully requests that the Court adopt its construction because it is consistent with the phrase's ordinary meaning and the purpose of claim construction, which is to resolve any disputes as to the meaning of claim terms and to provide definitions that can be understood and applied by the jury to the facts of the case. *Power-One, Inc. v. Artesyn Techs., Inc.*, 599 F.3d 1343, 1348 (Fed. Cir. 2010) ("The terms, as construed by the court, must 'ensure that the jury fully understands the court's claim construction rulings and what the patentee covered by the claims.'") (quoting *Sulzer Textil A.G. v. Picanol N.V.*, 368 F.3d 1356, 1366 (Fed. Cir. 2004).

G. Subcarrier Term ('230 Patent)

Term	University Proposal	Defendants' Proposal
Subcarrier (230: 2, 17) (*See also* discussion re '317 family below)	In a multi-carrier waveform, one of a number of carrier frequencies within a larger frequency band	In a MIMO multi-carrier waveform, one of a number of carrier frequencies within a larger frequency band

"Subcarrier" is a term of art in wireless communication systems and refers to one of a number of carrier frequencies that are used in a multi-carrier waveform. *See supra*, at 7-8; *see also* Wells Decl. ¶ 68; Ex. V at UMN0150017; Ex. W at 1; Ex. X at UMN0149562. Based on their proposed constructions, the parties appear to agree that

the term's ordinary meaning requires a subcarrier to be one of a number of carrier frequencies within a larger frequency band.

The dispute relates to Defendants' attempt to further limit the claimed subcarrier to waveforms generated by a MIMO (multiple-input multiple-output) transmission system. The ordinary meaning of the term does not support this requirement. Nor does the intrinsic evidence. The '768 and '230 patents repeatedly refer to subcarriers in OFDM systems that are not also MIMO. For example, a preferred embodiment of the '768 patent describes an OFDM transmission system having subcarriers without any mention of using multiple antennas (which is required for a MIMO system). Wells Decl. ¶ 71; '768 Pat. at 2:16-3:31, 5:4-6, Fig. 1; Wells Decl. ¶ 69. Similarly, the Figure 1 embodiment of the '230 patent includes OFDM (and thus subcarriers, *see* 4:35), but does not disclose multiple antennas. '230 Pat. at 4:14-44, Wells Decl. ¶ 69.

The extrinsic evidence further demonstrates that "subcarrier" does not require a MIMO transmission. For example, a doctoral thesis identified by Defendants as relevant extrinsic evidence describes conventional OFDM systems (which have subcarriers), and then proposes an improved OFDM technique using multiple antennas. Wells Decl. ¶ 70; Ex. Y at 249, 270. The thesis states that a conventional OFDM system can be improved by "using a set of transmit or receive antennas." *Id.* If subcarriers were only found in MIMO systems, the idea of improving a subcarrier-based system by using multiple antennas would make no sense.

H. Phase Rotate Term

Term	University Proposal	Defendants' Proposal
a diagonal matrix to phase rotate each entry of a symbol vector (230: 30, 64, 68)	a diagonal matrix that applies a set of phase offsets to the entries of a symbol vector, such as $diag(1, \alpha, \dots, \alpha^{N_t-1})$, to modify the phase of at least some of those symbols.	Indefinite

The disputed limitation is part of a larger phrase found in asserted dependent claims 30, 64, and 68 of the '230 patent. Each of those claims requires that the claimed linear transformation be based on two matrices, and that one of them be "a diagonal matrix to phase rotate each entry of a symbol vector." The terms "phase rotation" and "diagonal matrix" are mathematical in nature. The meaning of these terms and the examples in the '230 patent show that this limitation is not indefinite, as Defendants contend, and the proper construction is consistent with the University's proposal.

1. A diagonal matrix has specific properties.

The parties agree that a diagonal matrix is a matrix with non-zero values only on its diagonal. Joint Claim Construction Statement at 3. For example, the matrix A below is a 3x3 (meaning three rows and three columns) diagonal matrix:

$$A = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 0 & 3 \end{bmatrix}$$

Wells Decl. ¶ 72.

One property of a diagonal matrix relevant to the claim construction analysis is that multiplying an NxN diagonal matrix (meaning it has an equal number "N" of rows and columns) by a vector with N elements (meaning one column of "N" values) effectively multiplies each element of the vector by a corresponding value of the diagonal matrix. *Id.* ¶ 73. To illustrate this property, multiplying vector X= $\begin{bmatrix} x1 \\ x2 \\ x3 \end{bmatrix}$ by the diagonal matrix A above, will create the values $\begin{bmatrix} 1 * x1 \\ 2 * x2 \\ 3 * x3 \end{bmatrix}$. *Id.*

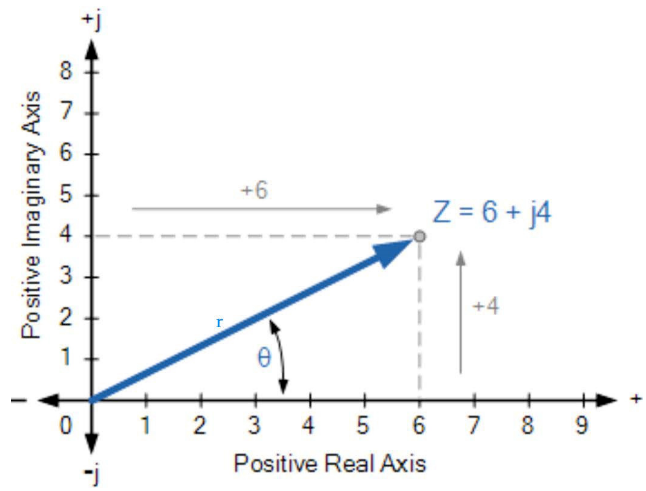
2. Phase rotation is a mathematical operation that applies to complex numbers.

The claim term "phase rotate" refers to a mathematical operation that applies to complex numbers. Complex numbers are useful for describing certain types of natural phenomena, such as the behavior of electronic circuits, and are used extensively in the '230 patent to describe the operation of various linear precoders. *Id.* ⁋ 74. They are called "complex" because they are represented mathematically as the sum of two numbers: a "real" number and an "imaginary" number (that is a multiple of the square root of negative one).[10] *Id.*

It is common to represent a complex number as a point on a two-dimensional graph called the "complex plane," with value on the horizontal axis representing the "real" portion of the number and the value on the vertical axis representing the "imaginary" portion. *Id.* ¶ 75. The graph below shows the complex number Z = 6 + j4

[10] *See generally* https://en.wikipedia.org/wiki/Complex_number.

on the complex plane, where "6" is the real portion and "j4" is the imaginary portion ("j" representing the square root of negative one in this instance):



Id.

As the figure also illustrates, a complex number can alternatively be described by specifying the length (r) and angle (θ, theta) of a line extending from the origin. *Id.* ¶ 76. The value "r" is called the "magnitude" of a complex number and the angle θ is called its "phase." *Id.* This notation is useful because it simplifies certain types of mathematical operations. *Id.* For example, the product of two complex numbers can be calculated by multiplying their magnitudes and adding their phases. *Id.* Thus, if a complex number is multiplied by another complex number that has a phase other than 0, the product of that multiplication will have a different phase than the original value. *Id.* This type of operation is sometimes referred to as "phase rotating" the original value, because it can be visualized as rotating the "arrow" representing the original value about the origin so that it points in a different direction. *Id.*

3. The proper construction is consistent with the ’230 Patent’s examples of phase rotating entries of a symbol vector.

As discussed previously for the Multiple Matrices Terms, the ’230 patent describes a linear precoder matrix Θ, which is defined as $\Theta = F_{N_t}^T diag(1, \alpha, \ldots, \alpha^{N_t - 1}), \alpha := e^{j2\pi/P}$. According to the patent, the application of this precoder matrix is equivalent to “phase-rotating each entry of the symbol vector s, and then modulating in a digital multi-carrier fashion, that is implemented by $F_{N_t}^T$.” ’230 Pat. Cert. of Correction at 6; Wells Decl. ¶ 77. In other words, applying the matrix Θ is mathematically equivalent to applying two matrices to a vector of symbols—first applying a diagonal matrix to “phase-rotate each entry of the symbol vector,” and then applying the matrix $F_{N_t}^T$ to performs “digital multi-carrier” modulation. ’230 Pat. Cert. of Correction at 11; Wells Decl. ¶ 77.

The diagonal matrix for phase rotation described in the ’230 patent contains the values $(1, \alpha, \ldots, \alpha^{N_t - 1})$. Wells Decl. ¶ 78. Because each of those diagonal values has a different phase, this operation changes the phase of each input symbols by a different amount. *Id.* The dispute here, however, arises from the first diagonal value, “1”, in the matrix, which does not change the phase of the first symbol in the input vector. *Id.* Maintaining the same phase for one input symbol and changing all the rest is consistent with the purpose of the phase rotation matrix, which is to create symbols with differing phases to achieve “diversity” and make it easier for a receiver to accurately decode transmitted symbols. *Id.* ¶ 79.

Consistent with the examples in the ’230 patent, the University’s proposal allows for the phase of the first symbol to remain unchanged and the rest be modified by the diagonal matrix with the qualifier, “to modify the phase of at least some of those symbols.” It is also consistent with the plain meaning of “phase rotate each entry of a symbol vector” because the diagonal matrix will create phase diversity by changing the phase of every symbol relative to each other. That can be achieved regardless of whether the phase of the first symbol is modified or stays the same. Defendants’ attempt to invalidate the claims containing this phrase is improper.

I. Null Subcarrier Term (’317 Family)

Term	University Proposal	Defendants’ Proposal
Null subcarrier (all asserted claims in ’317, ’185, and ’309 patents)	A subcarrier on which no value is intended to be transmitted during a specific time period	A subcarrier on which no value is intended to be transmitted during a specific time period, used to estimate carrier frequency offset

All asserted claims in the ’317 patent family recite the term “null subcarrier,” which is a type of training symbol sent from a transmitter to a receiver. Both sides agree that a null subcarrier is “a subcarrier on which no value is intended to be transmitted during a specific time period.” Defendants’ proposed construction, however, erroneously requires a specific use for the null subcarrier—namely that it be used to estimate a characteristic of the transmission system called “carrier frequency offset” (CFO).[11]

[11] CFO is the difference between the radio frequency assigned to communications between a transmitter and receiver, and the frequency of the signal actually received.

Defendants' proposal is not supported by the claim language. The claims do not require that the null subcarriers be used for any specific purpose. Moreover, they do not mention CFO estimation. Rather, estimating CFO is only mentioned in some dependent claims, but even those claims fail to say anything about using null subcarriers (*e.g.*, "wherein the transmission signals provide information for estimating a carrier frequency offset"). *See* '309 Pat. claim 17; *see also id.* at claim 23; '185 Pat. claim 10. The lack of a CFO requirement in the claims and its reference in dependent claims provide further support for Plaintiff's construction under the doctrine of claim differentiation. That doctrine, "which is ultimately based on the common sense notion that different words or phrases used in separate claims are presumed to indicate that the claims have different meanings and scope, normally means that limitations stated in dependent claims are not to be read into the independent claim from which they depend." *Karlin Tech., Inc. v. Surgical Dynamics, Inc.*, 177 F.3d 968, 971-72 (Fed. Cir. 1999) (citations omitted). If CFO estimation was somehow inherent in the concept of "null subcarrier,' the additional limitations in the dependent claims would be meaningless and unnecessary.

The ordinary meaning of "null subcarrier" is properly reflected in the parties' agreement of "a subcarrier on which no value is intended to be transmitted during a specific time period." Wells Decl. ¶¶ 80-81. This is also consistent with the specification's use of the term in the '317 patent family. '317 Pat. at 5:39-41; *see also id.*

This difference in frequency, which can be caused by slight hardware imperfections or by a moving receiver, can create transmission errors unless the receiver corrects for it. Wells Decl. ¶ 81.

While the specification states that null subcarriers can be used to determine CFO, the specification does not require it. As a result, there are no statements of manifest exclusion or restriction that would be necessary to deviate from the term's ordinary meaning. *See Thorner*, 669 F.3d at 1365.

J. Subcarrier Term ('317 Family)

Term	University Proposal	Defendants' Proposal
Subcarrier (all asserted claims in '317, '185, and '309 patents)	In a multi-carrier waveform, one of a number of frequencies within a larger frequency band	In a MIMO multi-carrier waveform, one of a number of carrier frequencies within a larger frequency band

The term "subcarrier" in the '317 patent family claims should be given the same (ordinary) meaning as in the '230 patent, which is "in a multi-carrier waveform, one of a number of carrier frequencies within a larger frequency band." *See* Wells Decl. ¶¶ 68-70. As with the '230 patent, nothing in the '317 family patent specifications or file histories justifies restricting this term to only MIMO-type transmissions. To the contrary, the '317 patent family states that OFDM transmitters can include both MIMO (multi-antenna) and single-input single-output systems (which are also called SISO or single antenna systems). '317 Pat. at 1:47-65.

K. Position Terms ('317 Family)

Terms	University Proposal	Defendants' Proposal
"position" and "positions" (all asserted claims in '317, '185 and '309 patents)	The location of a symbol in a block of symbols	Frequency range

All of the asserted claims in the ’317 patent family use the terms “position” and “positions” to refer to the location of a symbol in a block of symbols. This ordinary meaning is confirmed by the surrounding claim language. *IGT v. Bally Gaming Int'l, Inc.*, 659 F.3d 1109, 1117 (Fed. Cir. 2011) (“We caution that claim language must be construed in the context of the claim in which it appears. Extracting a single word from a claim divorced from the surrounding limitations can lead construction astray.”). For example, claim 1 of the ’309 patent recites “***inserting*** training symbols and null subcarriers ***within the two or more blocks*** of information bearing symbols ***at positions*** determined by the hopping code.”

Defendants’ proposal wrongly equates each “position” in a block of symbols with a “frequency range.” Neither the ordinary meaning of “position” nor the intrinsic record support this construction. A “position” is not a “frequency range.” For that reason, Defendants’ proposal should be rejected by the court.

L. Block Length Term (’317 Patent)

Term	University Proposal	Defendants’ Proposal
“block length” (317: 1, 19)	The number of symbols in a block	The number of subcarriers in a block of symbols

The two asserted claims of the ’317 patent recite a hopping code that determines the positions of null subcarriers in a block of symbols based, in part, on “a block length.” The “block,” in turn, refers to one of any number of “blocks of symbols” introduced earlier in the claim. The parties agree that a “block of symbols” is “a group of symbols for transmission at a given time.” Joint Claim Construction Statement at 3. Thus, it is

clear from the plain and ordinary meaning of the term "block length" and its use in connection with "blocks of symbols," that it refers to "the number of symbols in a block."

Defendants' proposal wrongly departs from the ordinary meaning by replacing the "symbols" in the blocks of symbols with "subcarriers" (which, in turn, they define to require multiple antennas). Moreover, the inventors use the term "subcarrier" elsewhere in the claims and would have not used the phrase "block of symbols" if the intent was a "blocks of subcarriers." The fact that the inventors chose to use the term "symbols," and not "subcarrier," is further evidence that Defendants' construction is wrong.

M. Block Forming Terms ('317 Family)

<table>
<tr><th>Terms</th><th>University Proposal</th><th>Defendants' Proposal</th></tr>
<tr><td>"form … blocks of symbols/output symbols"
(317:19; 185:9)</td><td rowspan="2">Plain and ordinary meaning</td><td rowspan="2">Generating blocks of symbols for transmission at consecutive times.</td></tr>
<tr><td>"forming blocks of symbols/output symbols"
(317:1; 185:1, 18; 309:1, 13)</td></tr>
</table>

Some claims in the '317 patent family refer to "forming" blocks of symbols (or output symbols). The claims also use the term "form" in a similar fashion. As noted previously, the parties agree that a "block of symbols" is "a group of symbols for transmission at a given time." Because this phrase has been defined, the remaining words "form" and "forming" can easily be understood by the jury and require no further construction. *Summit 6, LLC v. Samsung Elecs. Co.*, 802 F.3d 1283, 1291 (Fed. Cir.

2015) ("Because the plain and ordinary meaning of the disputed claim language is clear, the district court did not err by declining to construe the claim term.").

Defendants' proposed construction, by contrast, departs from the ordinary meaning of this phrase by unnecessarily changing form and forming to "generating" and by requiring that the forming be done "at consecutive times." The plain meaning of "forming … blocks…" does not have any temporal requirement, nor is there a requirement that it be done consecutively. Therefore, the Court should decline to deviate from the plain and ordinary meaning of the terms chosen by the inventors.

N. Symbol Adjacency Term ('317 Family)

Term	University Proposal	Defendants' Proposal
"inserting at least one training symbol adjacent to at least one null subcarrier" (185:6, 309:19)	**"training symbol"**: in a transmission system, a symbol having a predefined value that is transmitted by the transmitter to enable a receiver to determine a parameter that can be used to decode other transmitted symbols **"inserting at least one training symbol adjacent to at least one null subcarrier"**: placing at least one training symbol next to at least one null subcarrier	**"training symbol":** symbol with a predefined value that can be used by the device that receives the symbol to determine a physical characteristic of the transmitted signals **"inserting at least one training symbol adjacent to at least one null subcarrier":** inserting, within a block, at least one training symbol at an adjacent frequency to at least one null subcarrier

Two asserted dependent claims in the '185 and '309 patents recite "inserting at least one training symbol adjacent to at least one null subcarrier." This phrase further

defines the requirement from the respective independent base claims of inserting "training symbols and null subcarriers within two or more blocks of … information bearing symbols." '185 Pat. claim 1; '309 Pat. claim 16. As discussed previously, "training symbol" is a term of art in the field of communication systems, which refers to a symbol having a predefined value that is transmitted by the transmitter to enable a receiver to determine a parameter that can be used to decode other transmitted symbols. *See* Wells Decl. ¶ 82. Accordingly, the University proposes that "training symbols" be given that ordinary meaning.

Defendants' construction of "training symbols" is incorrect because it merely requires that training symbols be used to determine "physical characteristics of the transmitted symbols." Receiving any transmitted symbol inherently involves determining some "physical characteristic" of that symbol. *Id.* ¶ 83. Therefore, Defendants' construction reduces "training symbol" to any symbol with a predetermined value, a construction that is inconsistent with its ordinary meaning and renders the word "training" meaningless. *Id.*

The claims also require inserting the training symbol "adjacent to at least one null subcarrier." Consistent with the ordinary meanings of the word "adjacent," the University proposes that the phrase be construed to require that a training symbol be placed "next to" at least one null subcarrier. Building on their incorrect construction of "position" to mean "frequency range," Defendants' proposal improperly seeks to limit "adjacent" to "adjacent frequency." Nothing in the intrinsic evidence contains the words of manifest exclusion necessary to limit the claims with details from the specification.

VI. CONCLUSION

For the reasons stated above, the University respectfully requests that the Court adopt the University's proposed claim constructions.

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FISH & RICHARDSON P.C.

By: */s/ Lawrence K. Kolodney*
Conrad A. Gosen (#0395381)
gosen@fr.com
60 S. Sixth St., 3200 RBC Plaza
Minneapolis, MN 55402
Tel: (612) 335-5070

Attorney for Plaintiff
Regents of the University of Minnesota

FISH & RICHARDSON

Of Counsel:

Frank E. Scherkenbach
scherkenbach@fr.com
Lawrence K. Kolodney
kolodney@fr.com
Whitney A. Reichel
wreichel@fr.com
One Marina Park Drive
Boston, MA 02210-1878
Tel: (617) 542-5070

Aamir A. Kazi
Kazi@fr.com
1180 Peachtree Street NE
Atlanta, GA 30309
Tel: (404) 892-5005

Katherine D. Prescott
prescott@fr.com
500 Arguello Street, Suite 500
Redwood City, CA 94063
Tel : (650) 839-5070

John-Paul Fryckman
fryckman@fr.com
12860 El Camino Real, Suite 400
San Diego, CA 92130
Tel : (858)-678-5070

AVANTECH LAW

William R. Woodford (#0322593)
woodford@avantechlaw.com
80 South 8th Street, Suite 900
Minneapolis, MN 55402
Tel: (612) 895-2721

UNIVERSITY OF MINNESOTA

Brian J. Slovut (#0236846)
slov0002@umn.edu
Deputy General Counsel
Carrie Ryan-Gallia (#0390479)
ryang001@umn.edu
Senior Associate General Counsel
360 McNamara Alumni Center
200 Oak Street S.E.
Minneapolis, MN 55455-2006
Tel: (612) 624-4100

Attorneys for Plaintiff
Regents of the University of Minnesota